

Section Review

Knowledge

1. What are the benefits to an organism of being multicellular?
2. Describe the difference between cells, tissues, and organs. Give examples of each.
3. Name the two main plant systems. How do they differ?
4. Define the following terms:
 - a) dermal tissue
 - b) ground tissue
 - c) vascular tissue
 - d) xylem tissue
 - e) phloem tissue
5. What are the roles of the cuticle in plants?
6. Compare cells in the meristems to cells in other areas of the plant.
7. Write a short paragraph to describe the characteristics, location, and function of chloroplasts.
8. Write the word and chemical equations for photosynthesis.
9. What evidence is there for cytoplasmic streaming? Is this direct or indirect evidence? Explain.
10. Apart from photosynthesis, what other sequence of reactions occurs in plants to produce a gas?
11. Draw a cross section of a leaf showing spongy mesophyll and palisade tissues.
12. What is the difference between cohesion and adhesion? Explain how each process is involved in the transport of water in a plant.
13. The flowering of certain plants may be affected by the length of daylight that they are exposed to. Identify the three categories of daylight requirements that plants divide into, and give an example of the type of plant that belongs to each category.
14. Briefly describe changes that occur in cells during the formation of xylem vessels.
15. What are the functions of sieve tube cells and companion cells in phloem?

Applications

16. Consider the similarities and differences between plant and animal cells. Why are animals not able to manufacture their own food?
17. Compare and contrast the processes of photosynthesis and cellular respiration. Include reactants, products, and energy requirements.
18. Plant cells respond to a change in tonicity with increased or decreased turgor pressure. In the absence of a cell wall, predict what would happen to a blood cell placed in a hypotonic solution.
19. Using diagrams, describe how guard cells use turgor pressure to regulate the exchange of gases into and out of the leaf.
20. What important physiological role is played by air spaces located in the spongy mesophyll?
21. Using the terms cohesion, adhesion, pressure difference, and transpiration pull, explain the movement of water from the roots to the leaves.
22. What would happen to the growth of a shoot if a strong light source were placed below the plant? Explain your prediction.
23. Would you expect significant water movement to the leaves during the night? Explain your answer.
24. Discuss the transport of sugars, including the loading of phloem at the source. Include the role played by active transport.
25. Describe how the dermal tissue regulates gas exchange. How does it regulate the movement of water into and out of the plant? How are these two processes opposed to one another?

Extensions

26. Design an experiment to test whether phototropism or gravitropism has a greater effect on the growth of a plant.
27. If you were to attempt to improve on the experiments of the Darwins, Boysen-Jensen, and Went, what changes would you propose?



Help Wanted

Background Information

The application of engineering principles to cellular and molecular research is a rapidly growing field. Scientific and technological advances have given us an increased ability to understand how the cell works, opening the door to new treatments at the tissue, organ, and whole-body levels. People who have strong engineering skills and a background in biochemistry and cell biology have an opportunity to influence the future development of health care as well as industrial applications. Developing the right knowledge and skill sets begins with an interest in cutting-edge research and a desire to be part of a team that has the ability to shape the future.

Scenario

BIOMEDICAL ENGINEER

Biomedical Engineer required for new research facility. The successful candidate will have completed a degree in cellular and molecular biology and have an appreciation of engineering applications of transport systems in cells. This position requires teamwork, collaboration, and exceptional abilities in research and investigation. Applicants should be prepared to identify and explain a specific area of research related to the application of cellular transport in medicine or industry.

Research the Issue

Research current applications of cellular transport in industry or medicine in preparation for your job interview. Refer to the following guidelines to help you get started:

1. Identify an area of research to focus on. Will you choose an example from medicine or industry? Perhaps it is an area of particular interest to you because it has a direct impact on you, a friend, or a family member.
2. Use the Internet to locate current information on your area of study.
3. Try to connect with scientists, researchers, or practitioners in the field. Professional organizations and research facilities may be able to help. Check with your teacher for appropriate ways to contact scientists through Web sites or organizations in your area.
4. Find out if any of this research is being done in Canada, and specifically in Alberta. Who are the people involved and what can you find out about them?
5. What educational programs are available that would prepare you for a career in the field of your choice?

Analyze the Issue

6. Prepare a presentation for your job interview that will impress upon the interviewers your knowledge and interest in the area of research you have chosen. Include a discussion of:
 - why you chose the particular area of research
 - what you have found out concerning new, cutting-edge advances
 - who is involved in the research and where they are located
 - how this application of cellular transport could be adapted for practical use in medicine or industry

Address the Issue

7. Present your findings to the interview committee (your teacher and classmates). You may support your presentation with a short report, diagrams, posters, or electronic media.



The Impact of Environmental Factors on Plant Function

The short- and long-term effects of climate change on living organisms are subjects of certain areas of environmental research. Some plants and animals are considered to be **bioindicators**, because they respond quickly to environmental change in clearly defined ways. Plants, as primary producers in the food chain, have an important role in demonstrating the effects of climate change.

The ability of a plant to produce glucose depends on the number and activity of the chloroplasts present in its cells. Chloroplasts are the sites where photosynthesis occurs. Chemical energy, stored in the glucose produced through photosynthesis, is then used or stored by the plant. Animals that eat the plants are able to use this stored chemical energy in their own metabolic activities. For the production of glucose, cells require water and carbon dioxide in the presence of light energy. Are plant cells able to respond to their environments when the levels of carbon dioxide fluctuate?

Criteria for Success

As a research scientist you are asked to write a proposal to investigate whether plant cells are able to respond to their environments when the level of carbon dioxide fluctuates. Not all research proposals are accepted for funding and support. You must meet several criteria for approval of the proposal.

- Design an experiment to determine how the number of chloroplasts found in leaves of *Elodea canadensis* changes with exposure to different levels of carbon dioxide in the water.
- Use the knowledge and skills you have developed to consider how to monitor the levels of carbon dioxide in your experiment, and how to determine the number of chloroplasts present in the cells at the various carbon dioxide concentrations.
- Consider your hypothesis, the variables involved (controlled, manipulated, and responding), the procedure, and appropriate forms of data collection.
- Ensure that your proposal has all the elements necessary for a scientific investigation and can be efficiently and effectively carried out to provide quantitative data.

Procedure

- 1 State your question and hypothesis. Based on these, review what you learned in this unit that will help you to answer the

question and test your hypothesis. Identify the variables involved and ways to control major factors in the experiment. Design an experimental procedure to test your hypothesis. Involve at least two other people (classmates, teacher, friends, family) in a peer review to provide you with feedback on your procedure. You may wish to try your procedure if time and materials allow.

- 2 Determine the best format for presenting your research proposal—PowerPoint presentation, written report, oral presentation, poster, etc. Identify ways to present your key points that will encourage the approving body, made up of your teacher and/or classmates, to accept your proposal. Develop your proposal.
- 3 Consider how your results will address concerns about the impact of environmental conditions on plants, specifically the effect of carbon dioxide concentration. You may want to do some research to support your thinking. Address this matter of environmental impact in your proposal.

Analysis

Your research proposal will be assessed on problem-solving technique and communication skill using the rubric supplied by your teacher.

1. Review the rubric and the criteria for success. Assess your proposal and look for modifications to improve it.
2. Use the rubric for peer review prior to submitting the proposal for approval.
3. Consider other variables that may affect the number of chloroplasts present in *Elodea* leaves and may need to be controlled in your experiment. List these factors and suggest alternative experimental designs to address these factors.
4. Consider whether these other factors will affect your discussion of concerns about environmental conditions, climate change, and their effect on plants.

Reporting

5. Present your work in your chosen format.
6. Write a one-page summary report.

Unit Summary

C 1.0 Our current understanding of the cell is due in part to developments in imaging technology.

Key Concepts

- microscopy and the emergence of cell theory

Learnings

- From the time of Aristotle, people have been intrigued by the structure of living things. Van Leeuwenhoek, Hans and Zacharias Janssen, and Robert Hooke contributed to the understanding of structure through the development and use of microscopes.
- It is possible to estimate the size of any object viewed under a compound light microscope.
- Over time, scientists tried to support or disprove the theory of spontaneous generation. Louis Pasteur concluded that new organisms did not arise from spontaneous generation.
- The cell theory was developed after the discovery of the nucleus by Robert Brown and through the contributions of Schleiden, Schwann, and Virchow.
- Various imaging technologies and staining techniques were invented to identify the parts and functions of the cell more clearly. These include contrast and resolution enhancement, fluorescence microscopy, confocal technology, and electron microscopy.
- Many types of cell research at the molecular level are now possible. These include gene mapping, studies of transport across cell membranes, the three-dimensional structure of molecules, and investigations using green fluorescent protein (GFP) technology.

C 2.0 Living systems are dependent upon the functioning of cell structures and organelles.

Key Concepts

- cellular structures and functions, and technological applications of semi-permeable membranes
- active and passive transport of matter
- relationship between cell size and shape, and surface area to volume ratio
- use of explanatory and visual models in science

Learnings

- The cell operates as a functioning open system that uses processes involved in the acquisition of nutrients, excretion of wastes, and exchange of matter and energy.
- Plant and animal cells contain organelles with characteristic chemical structures and functions.
- The fluid-mosaic model suggests that the plasma membrane consists of a phospholipid bilayer with surface and transmembrane proteins suspended in it.
- The particle model of matter is useful to explain the role of the cell membrane in the transport of materials.

- Models and representations are useful to explain and illustrate the processes of diffusion, osmosis, endo- and exocytosis, and the role of the cell membrane in passive and active transport. Some important concepts are: concentration gradients, equilibrium, and the action of protein carrier molecules.
- Tonicity can be explained in terms of the concentration of solute, with different concentrations being described as hypotonic, hypertonic, and isotonic to each other.
- Knowledge about semi-permeable membranes, diffusion, and osmosis has been applied in industry and medicine in ways such as pharmaceutical research, synthetic membrane technology, peritoneal dialysis, and reverse osmosis.
- The ratio of surface area to volume is important to cell size and shape and may limit cell size.

C 3.0 Plants are multicellular organisms with specialized structures.

Key Concepts

- use of explanatory and visual models in science
- cell specialization in a multicellular organism (plants)
- mechanisms of transport, gas exchange, and environmental response in a multicellular organism (plants)

Learnings

- Multicellularity has advantages and disadvantages. Increase in an organism's size may necessitate the move to a multicellular level of organization. This size/organization relationship can be related to the specialization of plant cells, tissues, and organ systems.
- The structure of plants includes organ systems, the shoot system and root system; tissues, dermal, ground, and vascular tissues; and cells specialized for particular functions as a result of cell specialization.
- The leaf has specialized structures and functions. These include: chloroplasts, the sites of photosynthesis; palisade cells; spongy mesophyll cells; and vascular tissue, which consists of phloem and xylem.
- Gas exchange in plants in the light and the dark involves the action of guard cells and stomata, lenticels, and the process of diffusion through intercellular spaces.
- Water transport in plants can be explained in terms of cohesive and adhesive properties of water, root pressure in root hairs, and the process of transpiration through the xylem. Important concepts include turgor pressure and osmosis, diffusion, and tonicity.
- The pressure-flow theory explains sugar transport in terms of moving sugars from the source of production to the sink for use or storage.
- In plants, control systems and mechanisms include phototropism, gravitropism, and other types of tropisms. The understanding of these mechanisms is based on theories developed by the Darwins, Boysen-Jensen, and Went.

Unit Review

Vocabulary

- Using your own words, define the following terms:

adhesion
 auxin
 cell theory
 cellular respiration
 cohesion
 compound light microscope
 concentration gradient
 confocal laser scanning microscope
 control systems
 controlled experiment
 cytoplasmic streaming
 electron microscope
 fluid-mosaic model
 guard cells
 gravitropism
 hormone
 open system
 organ
 organelles
 photosynthesis
 phototropism
 plasmolysis
 pressure difference
 spontaneous generation
 stomata
 system
 tissue
 tonicity
 transpiration
 turgor pressure

Knowledge

C 1.0

- Explain the differences between the microscopes used by Hooke and van Leeuwenhoek.
- What problems in the use of early compound light microscopes were associated with lens technology? How were these problems overcome?
- In what way was Francesco Redi's investigation a controlled experiment?
- Outline the investigations conducted in the attempts both to prove and disprove the theory of spontaneous generation.
- What were the contributions to the cell theory made by each of the following?
 - Robert Brown
 - Matthias Schleiden
 - Theodor Schwann
 - Rudolf Virchow
- Define resolving power. What factor limits the extent of resolving power in the light microscope?
- Explain the advantages and disadvantages of using an electron microscope.
- What are the advantages of conducting cell research at the molecular level?
- State one advantage and one disadvantage of treating cells with stains.
- Describe how the use of fluorescence microscopy can increase our knowledge of cell structure.
- What is the unit of measurement most commonly used in measuring cells and their component parts?

C 2.0

- What is meant by an open system and why is a cell considered to be one?
- Consider the structures in a plant cell. Describe the function of the:
 - nucleus
 - central vacuole
 - cell wall
- How is the rate of diffusion affected by the surface area to volume ratio of a cell?
- What cell structures are visible through a light microscope?
- Compare the terms "diffusion" and "osmosis."

Unit Review

18. What processes must cells use to be able to survive as living systems?
19. Describe how the particle model is useful in understanding the movement of matter in living systems.
20. Explain the term “concentration gradient” by referring to solutes, solvents, membranes, diffusion, and osmosis.
21. Review the results of Activity C8. From these results, what inference can you make about the movement of iodine ions and starch across the membrane of the plastic bag? How do you account for this?
22. What is a vesicle? How do cells use vesicles in transport?
23. Explain how liposomes can transport both fat-soluble and water-soluble medications.
24. Describe the process by which water is desalinated at the McMurdo Research Station in Antarctica.
25. Use your textbook as a sample cell. Calculate the surface area, volume, and surface area to volume ratio. Would your “book cell” be efficient in the transport of materials? Explain your answer.
31. Define transpiration. What effect does transpiration have on the movement of water in a plant?
32. Describe the component parts of a vascular bundle.
33. Explain how root pressure moves water up a plant stem.
34. How are xylem and phloem the same? How are they different? Consider both structure and function in your answer.
35. Which transport tissue in plants is composed of dead cells? Explain your answer.
36. What is a tropism? Name two tropisms and describe how they regulate plant growth.
37. Describe a method for determining the presence of carbon dioxide in water.

C 3.0

26. Define the following terms:
 - a) meristem
 - b) shoot system
27. Give examples of the products of cell specialization. Explain how the cells in each example perform specialized functions in the organism.
28. List the three main types of plant tissue and state their functions.
29. Explain why light and chlorophyll are not considered to be reactants or products in the photosynthesis reaction.
30. What is the meaning of turgor pressure? Why is it important to plant cells?
38. Explain the importance of conducting controlled experiments, maintaining detailed records of observations, and connecting results to conclusions. Give an example of each of these aspects of the scientific process using your experience of the lab work from this unit.
39. If 16 protists fit across a low-power field of view having a field diameter of 4800 μm , what is the approximate size of each protist?
40. Describe three examples of the relationship between developments in imaging technology and the current understanding of the cell.
41. Using the particle model and the fluid-mosaic model, explain what is known about the cell membrane and transport of materials.
42. Draw a diagram showing the movement of water along a concentration gradient.
43. If a bowl of fresh strawberries is sprinkled with sugar, a few minutes later the berries will be covered with juice. Why?
44. Explain the process of facilitated diffusion and give an example.

Unit Review

45. Desert plants like cacti have prickly spines or needles, not large leaves. Chloroplasts are found in the cells of the stems. By contrast, rainforest plants tend to have large, flat leaves. Use what you know about surface area and diffusion to explain what may have influenced the structure of each plant.
46. Compare the surface area to volume ratio of various types of cells (i.e., nerve cells, blood cells, root hair cells) and relate your findings to the function of each cell type.
47. What is the advantage to the plant of cytoplasmic streaming that allows chloroplasts to move around in the cell?
48. Describe the means plants have for maintaining firm cells, able to hold the plant upright in the absence of a skeleton.
49. What is the advantage to the plant of having the palisade mesophyll cells arranged in a fence-like pattern?
50. Describe the experiment(s) you performed to determine the effect of control mechanisms in plants. Include your observations and conclusions.
51. Explain what happens during plasmolysis in plant cells and why it happens. What are the consequences for the plant? How can this process be reversed?
52. Explain the pressure-flow theory. According to this theory, what drives the movement of substances in the phloem?
53. *Plants act like animals at night!* Do you agree or disagree with this statement? Explain your answer.
54. Discuss the differences between water transport and sugar transport in plants.
55. Why is it important for cells in the stem, in particular, to be turgid? What control mechanism does a pea plant use to supplement the turgidity of the cells in its stems?
56. Explain how plants use specialized cells and processes to accomplish on a larger scale the same functions that a single cell carries out alone.
57. How did the cell theory replace the concept of spontaneous generation and revolutionize the study of life sciences?
58. Grade 8 students are just beginning to use the compound light microscope. Prepare a study sheet for them on the use, care, and handling of the instrument. Be sure to include the proper names of each of the parts.

Extensions

59. In terms of transport of materials, what problems might land-plants face that water-plants do not?
60. Would transport in the phloem tissue or xylem tissue require more energy input? Explain your answer.
61. How might hydroponics be used to determine whether or not a specific mineral is necessary for plant growth?
62. In the face of rising concerns over climate change and greenhouse gas emissions, describe how plants may be used as bioindicators of environmental conditions.
63. Stomata are usually found on the undersurface of leaves. Suggest reasons for this relationship and conditions that could affect the position of the stomata, as well as their number.
64. Bioethical issues are constantly in the news. Find a current article related to an issue in cell research. Identify and explain the two or more perspectives on the issue. Based on the information provided in the article, are you able to make an informed decision? What further information would you want to have?
65. What do you think was the most significant breakthrough in the study of living cells? Justify your choice by stating the implications of the breakthrough for future study.

Unit Review

66. Most cells have specialized shapes and sizes to make them suited to their particular function. Some have long appendages, some are cubic or cylindrical, and blood cells have a donut shape. Very few are spherical in shape, the yeast cell being an exception. Propose an explanation for the fact that few cells are spherical.
67. An exposed cut stem is left out of water for an extended period of time. Predict the effect on its ability to transport water. Justify your reasoning.
68. Design an experiment for the Canadian Space Agency to test the effects of gravitropism on germinating seeds under zero gravity conditions.
69. How do the following big ideas from this unit relate to one another: development of the microscope, understanding of molecular transport processes (diffusion, osmosis, active and passive transport), functioning of multicellular organisms in transporting materials? Use a presentation form of your choice to describe and illustrate the ways in which these ideas are connected.
70. Write the experimental procedure you would use to determine how a particular type of plant would react to various levels of fertilizer. Identify the controlled and manipulated variables in this investigation.
71. Find out about one plant research project currently being conducted at the Crop Diversification Centre South in Brooks, Alberta or at the Crop Diversification Centre North in Edmonton, or at Olds College in Olds, Alberta. Write a short report on the project of your choice.

Skills Practice

72. Write instructions, in your own words, for making a wet mount slide. Give your instructions to a friend or family member who has never made a wet mount. Are they able to follow your directions?

73. What is the purpose of making a hypothesis?
74. Using any five solid objects found in your classroom, complete the following table:

Object Name	Formula and Calculation of Surface Area	Formula and Calculation of Volume	Surface Area to Volume Ratio

75. Using instructions, mathematical formulas, and examples, explain the proper method for estimating the size of an object under low- and high-power magnification.

Self Assessment

76. In this unit, you have seen the relationship between increased scientific understanding and advancements in technology. How are science and technology dependent on one another? What role did societal values, needs, and wants have on the development of microscopy and knowledge of cell functioning?
77. Identify a possible career in each of the areas of plant study: gardening, horticulture, or agriculture. In a chart like the one below, identify what you would find to be interesting, challenging, or difficult about the job.

Career Choice: _____

Interesting	Challenging	Difficult

Would you like to have a career related to the study of plants? Why or why not?

78. Identify the topic in this unit that you found most interesting and explain why.